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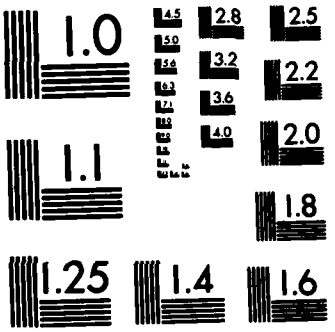

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Training the Practitioner: The Hydrologic Engineering Center Program

by

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Papers in this series have resulted from technical activities of the Hydrologic Engineering Center. Versions of some of these have been published in technical journals or in conference proceedings. The purpose of this series is to make the information available for use in the Center's training program and for distribution within the Corps of Engineers.

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TRAINING THE PRACTITIONER:
THE HYDROLOGIC ENGINEERING CENTER PROGRAM

William K. Johnson, M., ASCE[1]

Introduction

When the Hydrologic Engineering Center was established by the Corps of Engineers in 1964 it was given three principal tasks in hydrologic engineering: research, special assistance and training. The research was designed to be applied research, bridging the gap between the university and Corps' field offices. Special assistance meant to help Corps'offices on complex water problems. The training mission provided training for Corps' engineers in the theory and application of hydrologic engineering methods. These three tasks have been maintained over the years and have played a significant role in the success of the Center. While the principal focus of this paper will be upon training, the interrelationships between training, research and special assistance have contributed substantially to the success of the Center's training mission. Staff members are kept abreast of advances in technology through work on research projects. Practical experience is gained through applying the technology to field problems. Both an understanding of advanced technology and experience in its application are combined with theory to define the scope of what is taught in the training courses.

In addition to the contributions of the Center's research and special assistance programs the training program includes:

- o Training Courses
- o Workshops
- o Seminars
- o Individual Training
- o Cooperative Advanced Study Program
- o Video Tape Library
- o Publications

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1 Civil Engineer, The Hydrologic Engineering Center, Corps of Engineers, Davis, California. Presented at the ASCE National Convention, October 29, 1981.

Each activity will be discussed in the sections which follow. There are, however, still other aspects to the training effort. They include students who are practitioners with a wide range of backgrounds and experiences; courses and workshops which utilize a variety of learning techniques and experiences; and teaching devices and instructor skill. And lastly, there is the subject material itself which has a significant influence on what is presented, how it is presented, and the utilization of what is learned. All of these topics will also be discussed in subsequent sections.

Training Program

Training Courses. At the heart of the Center's training program are a series of regularly scheduled one or two week training courses. Table 1 shows a list of these courses. Each year approximately twelve courses are selected to be offered. Table 2 shows the courses to be offered during fiscal year 1982. Selection of the courses is made based upon present and future needs of the Corps' field offices. This is often influenced by the initiation of new federal programs such as flood plain management, national dam safety, nonstructural flood plain management, and hydroelectric power. All training courses are held in the Center's training classroom in Davis, California. This allows for ready use of the HEC's computer facilities in demonstration and workshop problems and ready use of the HEC staff. Typically six or eight HEC staff will be involved in a course. The facilities will accomodate up to 36 students hence the upper limit on class size.

Costs of conducting training courses range from $18,000 to $52,000 per course, depending upon whether it is one or two weeks and the amount of preparation required. New courses have greater development costs than those which have been offered before. Courses featuring technology which has not changed significantly are less costly than those where major advances have been introduced. Costs are reimbursed through tuition paid by all students. The tuition ranges from $700 to $1400 per course - again depending upon the total cost of the course including administrative charges.

TABLE 1

HYDROLOGIC ENGINEERING CENTER

TRAINING COURSES

Course Title

- o Analytical Techniques for Formulation of Nonstructural Plans
- o Dam-Break Analysis
- o Flood Frequency Analysis
- o Flood Plain Hydrology and Hydraulics
- o Flood Plain Management Planning

- o Ground Water Hydrology
- o Hydrologic Analysis of Floods
- o Hydrologic Aspects of Hydropower
- o Hydrologic Engineering for Planning
- o Hydropower Planning

- o Interior Flooding Hydrology
- o Planning for Hydrologic Engineers
- o Real Time Water Control
- o Reservoir System Analysis
- o Sediment Transports in Rivers and Reservoirs

- o Spatial Data Management Techniques
- o Statistical Methods in Hydrology
- o Unsteady Flow Analysis
- o Water Quality Aspects of Water Control
- o Water Quality Modeling of Rivers and Reservoirs

- o Water Supply Hydrology
- o Water Surface Profile Computation Using HEC-2 (Advanced)
- o Water Surface Profile Computating Using HEC-2 (Basic)

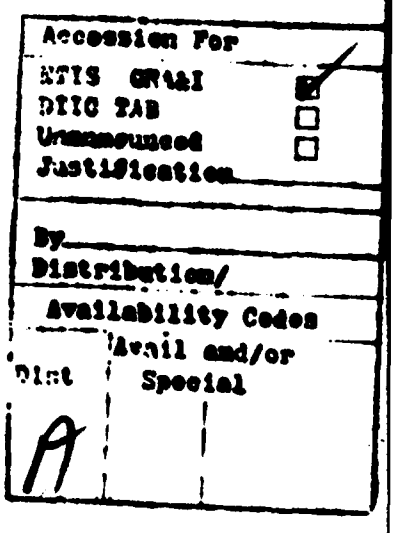


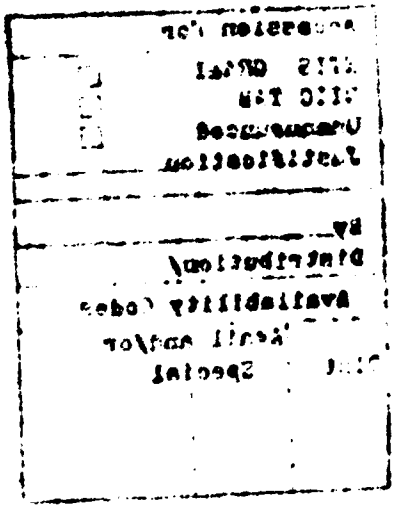
TABLE 2

HYDROLOGIC ENGINEERING CENTER

1981-82 TRAINING COURSES

Course Title

- Flood Plain Hydrology
- Hydrologic Engineering for Planning
- Ground Water Hydrology
- Statistical Methods in Hydrology
- Real Time Water Control
- Flood Plain Management Planning
- Water Surface Profile Computation Using HEC-2 (Advanced)
- Hydrologic Aspects of Hydropower
- Interior Flooding Hydrology
- Hydrologic Engineering for Planning
- Planning for Hydrologic Engineers



Workshops. At the request of Corps' District offices the Center will conduct workshops on specific technical topics at the District. This brings the Center's expertise directly to Districts throughout the country. These workshops are usually one to five days in length and involve one or two HEC staff. Often persons from the District with expertise on the subject are called upon to assist. Approximately five such workshops are held each year.

Workshops offer the advantage that training can be "tailored" to the needs of the office and personnel. From a large agenda of technical subjects those of greatest interest can be selected. For example, preparing input for an HEC computer program. Workshops allow an office to train large numbers of staff at one time. Often ten to fifteen staff will attend. Workshops also provide the opportunity for a Corps' office to invite nearby District or Division offices, staff from state and federal agencies, city, county and regional engineers, and persons from other organizations with a need for training. Not only do those attending learn the technical material but an opportunity is provided to interact with professionals from other organizations - often working on the same study. The size of the workshops depend upon the desires of the hosting Corps' office and facilities available. Typically attendance is twenty to thirty persons.

Costs of workshops range from $3,000 to $10,000 depending upon the number of days, the number of staff, location, and amount of preparation. Corps' offices provide funding and may or may not charge a tuition from those other than their own staff.

Occasionally workshops are held at the HEC in which case they take the shape of a mini-training course and are conducted in that manner. Funding is provided by the sponsoring office.

Seminars. Periodically the Center sponsors two or three day seminars on a topic of special interest and concern. Specialists from the HEC, Corps' offices, universities and other organizations are invited to attend and present papers. In order for the participants to interact in depth, attendance is usually limited to about 15 persons. Papers are presented followed by discussion. Since 1969 twelve such seminars have been held on such topics as: urban hydrology, sediment transport, nonstructural measures, spatial analysis and water quality. Proceedings of the seminars are published and listed in the Center's Publications Catalog.

Seminars provide the opportunity for training and information exchange at a relatively high level of technical knowledge. Frequently a seminar will assist in charting new directions in the Center's research, special assistance and training programs.

Individual Training. Individuals and small groups frequently visit the Center for training and assistance on specific projects. Within the context of that project they often receive training from various HEC staff on the technology being used. Such assistance and training may last several days or several weeks. On occasion engineers from Corps' field offices have worked and received training at the Center for six months or one year.

Cooperative Advanced Study Program. This year the Center initiated a cooperative program of advanced study in hydrologic engineering with the University of California, Davis, Department of Civil Engineering. The University campus is located about one-half mile from the Center's offices. Participants may enroll in the University's Graduate Studies Program and take graduate and undergraduate courses in hydrologic engineering. Concurrently, participants will work with the staff of the HEC, who will suggest possible research topics and teach academic courses in hydrologic engineering at the University. The program is one-year in length, and provides the opportunity to combine an academic study at the University with work and instruction in technology in which the Center has expertise.

Video Tape Library. There are over 200 video tapes in the Center's library. They provide instruction in each of the Center's principal areas of expertise: hydrologic and hydraulic analysis, water control systems analysis, and planning analysis. Most tapes were made during lectures in the Center's regular training courses and are accompanied by lecture notes used in the course. A few tapes were made especially for the video tape library to provide instruction on recent developments. Tapes made since 1979 are in color on 3/4 inch cassettes. Tapes prior to that date are black and white on either 3/4 inch cassettes or 1/2 inch reel to reel. The Center's Video Tape Catalog lists all the tapes available and related specifications.

Each year the Center loans several hundred tapes to Corps' offices, universities and other public and private organizations who need training assistance. They are used by individuals and small groups to learn both the theory and application of hydrologic engineering methods. A common need is for instruction on preparing input for and interpreting the output from computer programs. Tapes, through their ability to be run and rerun, provide the opportunity to learn the material in-depth. Some offices have developed in-house training programs centered around a series of tapes. Use of the video tape library has proven to be an effective and economical extension of the Center's training courses.

Publications. Each year the HEC distributes over 17,000 copies of its publications. They cover a wide range of technical subjects and have many different purposes. The types of publications include:

- Computer Program Documentation
- Research Documents
- Project Reports
- Training Documents
- Seminar Proceedings
- Reports on Hydrologic Engineering Methods
- Technical Papers
- Administrative Documents

Titles, costs and descriptive information may be found in the HEC Publications Catalog.

The HEC publications are used in training courses, workshops, in individual training, with video tapes, and in a variety of other ways. Because of their wide distribution they provide training to many individuals and organizations which do not have the opportunity to participate in the Center's formal training program. Some publications are designed for self-instruction. For example, computer program documentation and training documents. Others report on developments in the field and provide instruction indirectly. Whether the publications are used directly in training or provide instruction indirectly they are a significant means for advancing the training mission of the Center.

Students and Instructors

Students. Each year over 300 students from a variety of professional disciplines attend HEC training courses. Because of space limitations and the need to give Corps' persons first priority the number of students from outside the Corps' is quite small - between ten and twenty persons per year. While the number is necessarily limited there is a strong desire to involve professionals from other agencies. It is desired, for example, to have participants from the Federal Insurance Administration in a course on Flood Plain Management, or to have a representative from the Federal Energy Regulatory Commission in a course on Hydroelectric Power. The presence of such persons adds to the learning experience of all students. Other agencies which have attended include the National Weather Service, U.S. Geological Survey, Soil Conservation Service, Bureau of Reclamation and some state agencies.

Within the Corps' of Engineers students come from a variety of disciplines and with different levels of experience. A course like Hydrologic Engineering for Planning will draw engineers, economists, urban planners, environmental planners, geographers and computer system specialists. The common need is for

a basic understanding of hydrologic engineering. However, each comes from a quite different educational and professional background. A course such as Statistical Methods in Hydrology which focuses on a single aspect of hydrologic engineering will have almost exclusively hydrologic engineers. However, their experience and technical background can vary from that of a recent graduate who needs a better understanding of statistical methods, to the engineer who will be doing frequency analysis in hydrologic studies, to a supervising engineer with 20 years experience who desires a refresher on statistical methods because of a variety of related problems which have come up in his office. In such a course there is a single discipline but a wide range of experience. In the former example the experience level is similar, however, a variety of disciplines are involved. Both audiences pose a challenge to the instructors.

Students who are practitioners with real-world experience are a significant asset to the class. Several such students can add immeasurably to a class. During questions and reviews their observations can benefit both students and instructors. They frequently take the lead in workshop presentations and discussions and provide additional insight and understanding from their experience.

Instructors. The key to quality instruction is the blend of research, special assistance and training experience which each staff person brings to the course. While staff are assigned organizationally to research, special assistance and training branches, their work is not limited to these areas. Considerable flexibility exists. A person working in research will also assist District offices on planning, design and operation studies, and teach in training courses. Similar trilateral assignments are undertaken in the other branches. This translates into the person being knowledgeable in advanced technology, being practical in what is appropriate for application, and being able to communicate to a variety of disciplines, and range of experience and education.

These same qualities - knowledge, pragmatism, articulateness - are desired of guest speakers in the training courses. The Center invites guest speakers to speak because of their unique expertise and experience and to complement the perspective of the HEC staff.

Hydrologic Engineering

When the Center was established and given its name in 1964 hydrologic engineering was identified as,

> "...an area of civil engineering practice in which applications of professional knowledge of hydrology constitute key elements in the planning, design, construction, and operation of water resources developments." (1)

Such a broad definition has served to give the HEC direction technically and yet allow flexibility to adjust its program to changing technical, social and institutional needs. This growth and flexibility is nowhere better illustrated than with the technical subjects taught in the Center's training program. Table 3 shows the courses which were a part of the training program at four points in time. In 1965 two courses were offered - hydrologic probabilities and hydrograph analysis. By 1970 an additional five courses were in the program. By 1975 five more courses had been added and by 1980 there were ten more. At present there are twenty-three courses in the program. Ten to twelve of these courses are offered each year. This provides for balance in the Center's program. The growth is a natural phenomenon which reflects the early success of the Center's work, authorizations for increased levels of staffing and funds, availability of technical expertise, and the recognition of technical needs within the Corps and profession.

The core of the Center's program has always been, and continues to be, its computer models in hydrology, hydraulics, and reservoir system analysis (2). Most courses which the Center offers and most of the other aspects of the training program focus on these technical areas - both in theory and application. Related technical subjects which have been added to the Center's mission include: economic analysis, spatial data management, and structural and nonstructural planning. These subjects have both broadened and

TABLE 3

COURSES IN HEC TRAINING PROGRAM
FY 1965, 70, 75, 80

1965	1970	1975	1980
Hydrologic Probabilities	Hydrologic Probabilities	Hydrologic Probabilities	Hydrologic Probabilities
Hydrograph Analysis	Hydrograph Analysis	Hydrograph Analysis	Hydrograph Analysis
	* * *	Reservoir System Analysis	Reservoir System Analysis
	Reservoir System Analysis	Water Surface Profile Computations	Water Surface Profile Computations
	Water Surface Profile Computations	Water Quality Management	Water Quality Management
	Water Quality Management	Flood Plain Hydrology	Flood Plain Hydrology
	Flood Plain Hydrology	Ground Water Hydrology	Ground Water Hydrology
	Ground Water Hydrology	* * *	Hydrologic Aspects of Hydropower
		Hydrologic Aspects of Hydropower	Hydrologic Engineering for Planning
		Hydrologic Engineering for Planning	Sediment Transport
		Sediment Transport	Urban Hydrology
		Urban Hydrology	Water Quality Modeling
		Water Quality Modeling	* * *
			Unsteady Flow Analysis
			Analytical Planning Techniques
			WRC Frequency Analysis
			Real Time Control of Water Resource Projects
			Interior Drainage Hydrology
			Dam Break Analysis
			Water Supply Potential
			Spatial Data Management
			Nonstructural Flood Control
			Advanced HEC-2

complemented the Center's core work. The growth of training reflects similar growth in research and special assistance. Experience gained in the latter areas of work have been fed back into the training courses through both theory and application.

Training Course Content

Most students attending the training courses are college graduates who are now practitioners in their respective disciplines. They generally desire to learn new technical skills which will help them to do a better job in their work assignments. Consequently, the emphasis in the HEC training courses has always been to teach the technical subjects in an applied way, that is, to present concepts, principles and methods which can be applied and to illustrate with examples, discussion and hands-on workshops how this is done. The typical format for an HEC course include:

- o Lectures
- o Workshops
- o Reviews

Lectures. Each day's schedule contains from three to five lectures depending upon the length of each and the number of workshops. Most lectures are 50 to 75 minutes in length. Lecture topics generally are one of three types: theory, methods, or application. Presentations which develop the theory of particular phenomena e.g. rainfall-runoff relationships, equations of open channel flow, or sediment transport theory, are designed to be concise and to the point. The discussion is intended to set the stage for the methods, including computer programs. For additional theoretical explanation students are referred to textbooks and technical literature.

Most methods of analysis at the HEC are part of a computer program or are designed to be used in conjunction with a computer program. For example, unit hydrograph techniques are used in computer program HEC 1, Flood Hydrograph Analysis and techniques of risk analysis are taught as an extension

of the flood frequency analysis program. When a course is centered around a computer program e.g. HEC 2, Water Surface Profiles, the methods taught will be principally those associated with the program. Other courses not directly tied to a computer program e.g. Hydrologic Engineering for Planning discuss methods in a broader,more conceptual sense.

Lectures dealing with applications range from input instructions and output analysis to descriptions of case studies. Sometimes demonstrations using a large video screen and teletype terminal are used. Emphasis is on the use of the method or model in the solution of hydrologic engineering problems.

Workshops. There are usually one or two workshops scheduled each day. They range in length from one-half hour to four hours. Their purpose is to give students an opportunity to apply what they have learned in the lectures. Some workshops emphasize use of computer programs and require students to use the HEC computer facilities in the solution of their problems. Others emphasize "hand" solutions and stress an understanding of theory and methods used by the computer programs. Some workshops are done individually others in collaboration with several students. On occasion results are presented and discussed before the class. Frequently, a class will have students with considerable experience in an area covered by a workshop and these students contribute significantly in discussions of workshop findings.

The workshop has traditionally been the means by which theory, method and application are merged. Since the focus in HEC training is on teaching the application of theory and methods the workshop is central. Problems developed for workshops are for the most part drawn from projects worked on by the staff. As is often the case such problems must be shortened and simplified to be worked within the time available, however, every effort is made to preserve the reality of the problem. Workshops are frequently updated and modified in subsequent courses. Improvements are made, modifications to computer code adapted, and advances in technology inserted. To date over 250 workshop problems have been developed for use in the training

courses. In most cases solutions are also developed and discussed during the review.

Review. The third principal activity in each course, each day, is review of the previous day's workshops and lectures. The purpose of review is to provide an opportunity for discussion after the students have had time to think about and review the material overnight. The review, conducted by one of the staff from the previous day, reinforces teachings and provides an opportunity to ask additional questions before the course moves on to the next topic. Often the review and subsequent discussions are some of the most beneficial parts of the class.

Training Equipment

To aid in both classroom and group or individual instruction the HEC has a variety of equipment available. This includes,

- Mini-computer/high speed Remote Job Entry (RJE) terminal
- CRT (Cathode ray tube) terminals
- Teletype terminals
- Digitizers
- Plotters
- Video screens

This equipment aids the training of students in two ways. Its presence and use by HEC staff serves as an example of the application of advanced computer hardware in hydrologic engineering and water resources planning and familiarizes students with its use. When it is used directly in training either through lecture demonstrations or workshops it gives students hands-on experience. While not all students have access to this equipment in their offices they have the opportunity to come to HEC on temporary assignment, have HEC do the analyses, go out to contract, or request their office to obtain the desired equipment. These options are usually sufficient to make the equipment accessible if the need exists.

Computers. Currently the Center has a Harris 500 mini-computer in-house, and a Cope 1200 terminal both which can be connected to CDC 6600/7600 computers at Lawrence Berkeley Laboratory in Berkeley, California and the Boeing Computer System in Seattle, Washington. The in-house facilities aid the students in obtaining faster turn-around for their problems. Often data cards have already been punched and are made available to the students at the appropriate time in the workshop. This also speeds turn-around. During the workshops HEC staff use of the computer is given a lower priority than that of the students.

CRT terminals. Both graphics and alpha-numeric CRT's are available for use and demonstration. A Tektronix 4027 color, refresh graphics display and Tektronix 4014 storage tube CRT are used. These devices provide students with the capability to display data output from the HEC models in graphical and tabular form. A wide variety of display options from river cross-sections to hydrographs to geographic data are available.

Teletype terminals. Both CRT's and teletype or printer terminals are used in teaching the interactive capability of HEC computer programs. Teletype terminals have the advantage of being portable. Some workshop problems are worked by dividing the class into small groups of four to six, accessing the Boeing Computer via a telephone and teletype terminal in different offices at HEC, and through this hook-up making hydrologic and economic analyses. In practice such a hook-up could be done in the field from an office or motel room.

Digitizers. The Center's program in spatial data management makes use of the digitizing equipment to establish files of various types of geographic data - coordinates, elevations, and natural features. The Center uses both an Altek AC90SM and Tektronix Graphics Tablet (4953) digitizer.

Plotters. The Center's plotting devices include plots from three high speed printers: a Zeta 3600 plotter (in-house), Printronix plotter (in-house) and Calcomp plotting capability at Lawrence Berkeley Laboratory. A number of the Center's

hydrologic models use plots of data in their output displays. In addition several graphics packages are also used in analysis.

Video screen. A 72 inch Sony video screen is used in the classroom for demonstrations and for viewing video tapes. The screen has been linked to a Tektronix CRT and the CRT linked to the Boeing Computer System via a telephone hook-up. The data displayed on the video screen could be output from a computer program which computes economic, hydrologic and structure information in flood hazard areas. The Tektronix (or Teletype) terminal allows interactive communication with the computer program - all of which is displayed on the video screen and viewed by the students in the classroom.

Conclusions

Training by the Hydrologic Engineering Center includes a variety of activities and materials from training courses to publications. Staff involved in training spend a portion of their time in applied research and special assistance. These two factors are, in the author's opinion, the most important reasons for the effectiveness of the Center's training program. The diversity of training means has been discussed previously and their merit should be obvious. The trilateral activity assignments - training, research, special assistance - for HEC staff perhaps needs additional emphasis. When a staff person comes into a training classroom, or instructs individuals or groups he or she brings a combination of the education and experience of a university researcher, a practitioner, and a teacher. This is a rare combination. Not only within government and the private sector but also, perhaps to a lesser degree, in the academic world where research is often emphasized to the exclusion of both teaching and consulting. It is not the researcher with much theory and little practice who is training. And it is not the practitioner with much practice and little appreciation of new technologies. Nor is it the trainer with communication skills but short on technical knowledge and experience. Rather it is a professional with the the best qualities of all these which is brought to the training program.

The fact that the staff can work in each of three areas is, of course, tied to the fact that HEC has a mission in these three areas. This also is unique. Most public and private organizations do not have such functions centralized in single organizational unit. Rather such units are separate one from another. This combination is the key not only to the effectiveness of the training mission but to the Center as a whole.

References

1. U.S. Army Corps of Engineers, "Memorandum A: Hydrologic Engineering Associated with Survey Studies:, Washington D.C., January 1965.

2. Feldman, Arlen D. "HEC Models for Water Resources System Simulation: Theory and Experience", in Advances in Hydroscience, Vol. 12, 1981.

3. Eichert, Bill S. "Experiences of the Hydrologic Engineering Center in Maintaining Widely Used Hydrologic and Water Resource Computer Models", The Hydrologic Engineering Center, Technical Paper #56, November 1978.

4. Peters, John C. "Institutional Support of Water Resource Models", The Hydrologic Engineering Center, Technical Paper #76, May 1980.

TECHNICAL PAPERS

Technical papers are written by the staff of the HEC, sometimes in collaboration with persons from other organizations, for presentation at various conferences, meetings, seminars and other professional gatherings.

Price
$2.00 each

1 Use of Interrelated Records to Simulate Streamflow, Leo R. Beard, December 1964, 18 pages.

2 Optimization Techniques for Hydrologic Engineering, Leo R. Beard, April 1966, 22 pages.

3 Methods of Determination of Safe Yield and Compensation Water from Storage Reservoirs, Leo R. Beard, August 1965, 17 pages.

4 Functional Evaluation of a Water Resources System, Leo R. Beard, January 1967, 28 pages.

5 Streamflow Synthesis for Ungaged Rivers, Leo R. Beard, October 1967, 23 pages.

6 Simulation of Daily Streamflow, Leo R. Beard, April 1968, 15 pages.

7 Pilot Study for Storage Requirements for Low Flow Augmentation, A. J. Fredrich, April 1968, 26 pages.

8 Worth of Streamflow Data for Project Design - A Pilot Study, D. R. Dawdy, H. E. Kubik, L. R. Beard, and E. R. Close, April 1968, 17 pages.

9 Economic Evaluation of Reservoir System Accomplishments, Leo R. Beard, May 1968, 20 pages.

#10 Hydrologic Simulation in Water-Yield Analysis, Leo R. Beard, 1964, 20 pages.

#11 Survey of Programs for Water Surface Profiles, Bill S. Eichert, August 1968, 35 pages.

#12 Hypothetical Flood Computation for a Stream System, Leo R. Beard, April 1968, 22 pages.

TECHNICAL PAPERS (Continued)

Price
$2.00 each

#13 Maximum Utilization of Scarce Data in Hydrologic Design, Leo R. Beard and A. J. Fredrich, March 1969, 16 pages.

#14 Techniques for Evaluating Long-Term Reservoir Yields, A. J. Fredrich, February 1969, 32 pages.

#15 Hydrostatistics - Principles of Application, Leo R. Beards, July 1969, 15 pages.

#16 A Hydrologic Water Resource System Modeling Techniques, L. G. Hulman and D. K. Erickson, 1969, 39 pages.

#17 Hydrologic Engineering Techniques for Regional Water Resources Planning, Augustine J. Fredrich and Edward F. Hawkins, October 1969, 26 pages.

#18 Estimating Monthly Streamflows Within a Region, Leo R. Beard, Augustine J. Fredrich, Edward F. Hawkins, January 1970, 18 pages.

#19 Suspended Sediment Discharge in Streams, Charles E. Abraham, April 1969, 20 pages.

#20 Computer Determination of Flow Through Bridges, Bill S. Eichert and John Peters, July 1970, 30 pages.

#21 An Approach to Reservoir Temperature Analysis, L. R. Beard and R. G. Willey, April 1970, 30 pages.

#22 A Finite Difference Method for Analyzing Liquid Flow in Variably Saturated Porous Media, Richard L. Cooley, April 1970, 47 pages.

#23 Uses of Simulation in River Basin Planning, William K. Johnson and E. T. McGee, August 1970, 28 pages.

#24 Hydroelectric Power Analysis in Reservoir Systems, Augustine J. Fredrich, August 1970, 15 pages.

#25 Status of Water Resource Systems Analysis, Leo R. Beard, January 1971, 13 pages.

#26 System Relationships for Panama Canal Water Supply, Lew G. Hulman, April 1971, 17 pages.
This publication is not available to countries outside of the U.S.

TECHNICAL PAPERS (Continued)

Price
$2.00 each

#27 System Analysis of the Panama Canal Water Supply, David C. Lewis and Leo R. Beard, April 1971, 13 pages.
This publication is not available to countries outside of the U.S.

#28 Digital Simulation of an Existing Water Resources System, Augustine J. Fredrich, October 1971, 31 pages.

#29 Computer Applications in Continuing Education, Augustine J. Fredrich, Bill S. Eichert, and Darryl W. Davis, January 1972, 23 pages.

#30 Drought Severity and Water Supply Dependability, Leo R. Beard and Harold E. Kubik, January 1972, 18 pages.

#31 Development of System Operation Rules for an Existing System by Simulation, C. Pat Davis and Augustine J. Fredrich, August 1971, 20 pages.

#32 Alternative Approaches to Water Resource System Simulation, Leo R. Beard, Arden Weiss, and T. Al Austin, May 1972, 12 pages.

#33 System Simulation for Integrated Use of Hydroelectric and Thermal Power Generation, Augustine J. Fredrich and Leo R. Beard, October 1972, 22 pages.

#34 Optimizing Flood Control Allocation for a Multipurpose Reservoir, Fred K. Duren and Leo R. Beard, August 1972, 15 pages.

#35 Computer Models for Rainfall-Runoff and River Hydraulic Analysis, Darryl W. Davis, March 1973, 46 pages.

#36 Evaluation of Drought Effects at Lake Atitlan, Arlen D. Feldman, September 1972, 15 pages.
This publication is not available to countries outside of the U.S.

#37 Downstream Effects of the Levee Overtopping at Wilkes-Barre, PA, During Tropical Storm Agnes, Arlen D. Feldman, April 1973, 22 pages.

#38 Water Quality Evaluation of Aquatic Systems, R. G. Willey, April 1975, 22 pages.

#39 A Method for Analyzing Effects of Dam Failures in Design Studies, William A. Thomas, August 1972, 29 pages.

TECHNICAL PAPERS (Continued)

Price
$2.00 each

#40 Storm Drainage and Urban Region Flood Control Planning, Darryl Davis, October 1974, 40 pages.

#41 HEC-5C, A Simulation Model for System Formulation and Evaluation, Bill S. Eichert, March 1974, 28 pages.

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